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Advisory Circular for Performance Standards, Retread, Repair and Alterations of Aircraft Tires

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[AC No. 145-XX]

Advisory Circular for Performance Standards, Retread, Repair and Alterations of Aircraft Tires

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Draft advisory circular and request for comments.

SUMMARY: The draft Advisory Circular (AC) is intended to provide guidance for the development, qualification, and approval of aircraft tire repair and retread process specifications, and the use of special nondestructive inspection techniques. It also provides information related to certain rule changes having particular emphasis on aircraft tires used on transport aircraft in order that tire reliability will be enhanced, and the incident of tire failure decreased.

DATES: Comments must identify the AC No. 145-XX and be received on or before May 18, 1981.

ADDRESSES: Send all comments on the draft advisory circular to: Federal Aviation Administration, Attention: General Aviation and Commercial Branch (AWS-340), 800 Independence Ave., S.W., Washington, D.C. 20591.

FOR FURTHER INFORMATION CONTACT: Angelo R. Mastrullo, General Aviation and Commercial Branch, Aircraft Maintenance Division, Office of Airworthiness, Federal Aviation Administration, 800 Independence Ave., S.W., Washington, D.C. 20591; Telephone (202) 426-8204.

Comments received on the draft AC may be inspected in Room 313, FAA Headquarters Building (FOB-10A), 800 Independence Ave., S.W., Washington, D.C. 20591, between the hours of 8:30 and 5:00 p.m.

SUPPLEMENTARY INFORMATION:

Comments Invited

Comments are solicited from all interested persons. A copy of the draft AC referenced herein may be obtained by contacting the person identified under "For Further Information Contact".

Discussion of the Draft Advisory Circular

This advisory circular provides INTERIM guidance for the inspection, repair, and retreading of aircraft tires to enhance tire reliability and decrease the incidence of tire failure.

The FAA's safety surveillance and analysis of aircraft tires with respect to cause of tire failure disclosed that complex landing gear systems, unprecedented high maximum aircraft operating weights, the operation of aircraft at higher taxi speeds on long taxi distances, and the quality of the inservice tire maintenance were among the significant factors in tire failures.

In the interest of safety to meet the increasingly severe tire operation conditions, Federal Aviation Regulations (FAR) Part 25, Airworthiness Standards: Transport Category Airplanes, and Technical Standard Order TSO -C62c, Aircraft Tires, were amended to incorporate updated and improved minimum performance standards applicable to main landing gear and nose wheel aircraft type design standards covering tire loads and speed ratings.

In keeping with those improved requirements, in the interest of safety, the FAA has decided to issue interim guidance by way of this advisory circular covering tire retread process specifications that are consistent with the test and dynamometer testing specified in the TSO under which the tire was built or requalified by testing.

The FAA has recognized the need to identify minimum performance levels for aircraft tire retreading, inspection, repair and retreading process specifications predicated upon substantial data. The FAA anticipates future data inputs from two major sources. The Office of Airworthiness has established a project plan agreement with the Transportation System Center (TSC) in Cambridge, Mass., through the FAA Technical Center in Atlantic City, N.J., to develop this technology to assure the continued airworthiness of aircraft tires.

The object of this project is to set forth standards for inservice tire qualifications, tests, inspections, and will include life and retread limits for these tires. It will also establish standards for nondestructive inspection which will include the latest state-of-the-art technology. In addition, the FAA will rely on aircraft tire manufacturers who are required to furnish the FAA with maintenance data as a condition of TSO authorizations that include the inspection criteria for tires to determine the eligibility of used tires to be continued in service. Recapping procedures are required to be included in the maintenance information along with any specific repair methods applicable to the tire and special nondestructive inspection techniques.

The recommendations received from the FAA aircraft tire project, along with the tire manufacturers' data provided the FAA, will be evaluated and the analysis of the findings will be used to update this interim AC.

Issued in Washington, D.C., on March 12, 1981.

George J. Pour,

Acting Director of Airworthiness.

AC145-XX—Advisory Circular

Dated: March 12, 1981.

Subject: Performance standards, retread, repair and alterations of aircraft tires.

1. *Purpose.* This advisory circular (AC) provides interim guidance for the development, qualification, and approval of aircraft tire repair and retread process specifications, and the use of special nondestructive inspection techniques. It also provides information related to certain rule changes having particular emphasis on aircraft tires used on transport aircraft in order that tire reliability will be enhanced, and the incidence of tire failure decreased.

2. *Related FAR.* FAR Part 25, Airworthiness Standards; Transport Category Airplanes, FAR Part 43, Maintenance, Preventative Maintenance, Rebuilding and Alteration, Technical Standard Order —C62c —Aircraft Tires. FAR Part 145, Repair Stations.

3. *Related Reading Materials.* TSO —C62, —C62a, —C62b and —C62c, Aircraft Tires. Tire manufacturers maintenance and repair instructions.

4. *Background.* Federal Aviation Administration (FAA) Technical Standard Order TSO —C62c —Aircraft Tires, which sets forth the minimum performance standards applicable to the main landing gear and nose wheel aircraft tires, has been amended to incorporate updated and improved minimum performance standards. In addition, FAR Section 25.733 was amended to include more comprehensive transport category airplane type design standards related to tire loads and speed ratings. Those revisions were necessary in the interest of safety to meet increasingly severe tire operating conditions.

5. *Terminating the Use of Certain Tires.* Tires manufactured and approved under TSO —C62, —C62a, or —C62b may be continued to be manufactured under the provisions of their original approval and be continued in use on aircraft except that after December 31, 1982, no person may identify or mark a tire having a speed rating above 160 mph with those TSO numbers (Ref: TSO —C62c Paragraph (d)).

6. *Ground Load.* The ground loads which tires must support is based on the most critical combination of aircraft gross weight (up to maximum ramp weight), center of gravity position, and the effect of engine thrust, reacted by inertia at the airplane center of gravity on each main wheel tire and nose wheel tire with some exceptions.

a. *Dynamic Loading.* Since the maximum ramp weight of the airplane may be significantly greater than the maximum take-off weight, it is considered important in relation to the tire design. To account for dynamic loading conditions, and to be consistent with TSO standards, the FAR specify limiting ground reaction loads for

aircraft tires in terms of the tire load rating (Ref: FAR Section 25.733(a)(b) and (c)).

b. *Turning.* Turning loads subject the aircraft landing gear structure, wheel carriage, rims and tires to high loads. Turning loads should be computed using the most critical combination of ramp weight, center of gravity position, and engine thrust, reacted by inertia at the airplane center of gravity on each main wheel tire and nose wheel tire.

7. *Multiple Mounted Tires.* When more than one wheel and tire are mounted on a single landing gear axle, disproportionate loads on individual tires may occur. Such unequal tire loading between adjacent tires may cause temporary overloading of individual tires and subsequent tire failure.

a. *Overload Test.* The FAA has concluded that derating the main wheel tire rated load by 7 percent (i.e., a load factor of 1.07), in combination with other changes, is appropriate. The change requires high-speed tires to withstand an overload of 1.61 times the present load rating (Ref: FAR Section 25.733 (c), (1), and (2)).

b. *Matching Tires.* To assist in equalizing loads on pairs of tires on the same axle, it is recommended that tire pairs, be from the same manufacturer, be inflated to the same tire pressure, and have equal amounts of tread on each tire. These measures will help ensure equal deflection of both tires on an axle. A slight difference in tire diameter between pairs can cause excessive deflection in the larger tire, with consequent overheating; this can result in sidewall damage.

8. *Technical Data Requirements.* Manufacturers are required to provide the FAA with tire speed and load rating, rated inflation pressure, tire mold skid depth, size, width, outside diameter, nominal loaded radius at rated load and inflation pressure, permissable tolerance on the normal loaded radius, the actual loaded radius of the test tire at rated load and inflation pressure, weight, static unbalance of test tire, wheel rim designation, and manufacturer's part number. For high-speed tires a load deflection curve at loads up to 1.5 times load rating, and a summary of the loan-speed-time parameters used in the dynamometer test, are also required. The term "high-speed tire" as used herein means a tire tested at a speed greater than 120 miles per hour (mph). (Ref: TSO–C62c, Paragraph (c)(1)).

9. *Maintenance and Repair instructions.* Manufacturers are required to furnish the FAA with maintenance data that includes the inspection criteria for tires to determine the eligibility of used tires to be continued inservice. Recapping procedures must be included in the maintenance information along with any specific repair methods applicable to the tire and special nondestructive (NDT) inspection techniques (Ref: TSO –C62c, Paragraph (c) (2)).

10. *Retread, Repair and Alteration of Aircraft Tires.*

a. *Retread.* The term "retread", for the AC, refers to several means of restoring a used tire by renewing the tread alone, or by renewing the tread plus one or both sidewalls. It refers as well to the process of extending new sidewall material to cover the bead area of the tire. Repairs are included in the retreading of tires. The retread and repair of a tire is considered to be a major repair because it cannot be done by an elementary operation and, if improperly done, would affect the airworthiness of the tire. The terms recap and recapping as used in this AC are synonymous with the terms retread and retreading.

b. *Data.* A repair station that is certificated to retread aircraft tires is required by FAR Section 145.33 to perform that work in accordance with a process specifications approved by the FAA. Before the process specification is approved by the FAA, it is required to meet the requirements of FAR Section 43.13(a) and (b), and be qualified by dynamometer testing. In addition, testing such as cross section sliver inspection, NDT inspection, etc., may be required. The manufacturer of an aircraft tire is now required to furnish maintenance data that includes maintenance and repair, recapping information, and special NDT inspection techniques. Such information provided by a tire manufacturer does not constitute an approved process specification. However, such data may be acceptable for use by a retreading agency in developing its process specifications to be submitted for approval. Required testing for approval is as follows:

(1) *For retreading tires manufactured under TSO –C62b,* the process is required to meet the requirements of FAR Section 43.13(a) and (b), be qualified by the test and dynamometer testing as outlined in AC 43.13–1A, Acceptable Methods, Techniques, and Practices, Aircraft Inspection and Repair, Chapter 8, Paragraph 332. Aircraft tires manufactured under TSO –C62b may continue to be retreaded using FAA approved process specifications for the TSO –C62b tires for use on aircraft.

(2) *Since the revised TSO –C62c* –Aircraft Tires, contains updated and improved minimum performance standards, repair stations who retread TSO –C62c tires will be required to requalify their retread process specifications to substantiate that the process can produce a product that meets the requirements of FAR Section 43.13 (a) and (b), and be qualified by the test and dynamometer testing as outlined in the TSO under which the tire was built.

(3) *Aircraft tires manufactured under TSO –C62b* which are requalified to TSO –C62c in order to remain a –C62c tire will be required to be retreaded under a process specification approved by the FAA for use on a –C62c tire. If any other process is used the tire will revert back to a –C62b aircraft tire.

c. *Performance.* The maintenance performance rules of FAR Section 43.13(a) and (b) state in part that, a product after undergoing maintenance shall be at least equal to its original or properly altered condition. This makes it necessary for a tire on which maintainance was performed to continue to meet the requirements outlined in the TSO under which it was built or qualified by testing. Retread tires are required to meet the same qualifications as when the tire was new in regard to speed rating, load rating, size, material, weight, skid depth, etc. Any deviations from the specifications under which a tire was built or qualified by testing would be an alteration to the tire and it would be considered a new product. As a new product, it would be necessary for the altered tire to be tested for approval under the TSO, and, be approved for use on each aircraft of which it would be a part.

11. *Tire Repairs.* The following represent industry practices regarding aircraft tire repairs.

a. *For high-speed tires:*

(1) *Tread Area.* Cuts, cracks, or other tread injuries 1½ inches in length and ¼ inch in width or less on the first cord body ply, and which do not extend through more than 40 percent of the actual tire cord body plies, may be repaired without an inside reinforcement. However, any tread injury repaired by skiving or resping methods must not have the final repair greater than 2 inches in length.

(2) *Major Tread.* Repairs to tread areas are limited to six (6) per tire and must be no closer than 60 degrees apart along the tire circumference. Major repairs consist of repairs to tread injuries that penetrate a distance equal to 40 percent of the actual tire cord body plies, and are 1½ inches in length or less on the first cord body ply.

(3) *Tread Injuries.* Injuries that are less than major repairs are not limited.

(4) *Punctures.* Punctures that penetrate through the cord body are not repairable.

(5) *Sidewall Rubber.* Surface defects of any degree (checking radial and circumferential cracks, cuts and snags) may be repaired provided the injuries do not penetrate into the cord body fabric plies.

(6) *Sidewalls.* Sidewalls that display a significant amount of ozone cracking or weather checking shall be veneered during retreading. Retreaders must be equipped to recover sidewalls on all of an airline's tire sizes processed by a particular retreader.

(7) *Bead area.* Bead areas must be free of cuts, snags, separations, deformations or other irregularities. Minor damage to the bead area may be repaired provided the cord body plies are not damaged.

(8) *Bead seal.* The bead seal must not be affected or intersected by impressions or depressions.

(9) *Bead Face and Bead Heel.* Those areas must be smooth.

(10) *Bead Toe.* The bead toe must be trimmed so that no edges are exposed above the bead face and so that any bead toe flash remaining does not protrude more than ⅛ inch from the face contour of the bead. If trimming of the bead toe is necessary, the trimming shall not cut or expose the tire cord material or more than one layer of chafer fabric.

(11) *Chafer Strip.* Minor injuries in the chafer strip or slight tire tool injuries in the general bead area, if they do not extend into the plies of the tire and there is no sign of separation in the bead area, can be repaired. Loose or blistered chafer strips can be repaired or replaced.

(12) *Inner Liner.* Inner liner surface damage and defects other than liner splices that are less than two inches in length, may be repaired. A maximum of ten of these repairs are acceptable with no more than three repairs in any one quadrant. Liner splice

damage and defects may be repaired if less than ten inches in length.

(13) *Exposed Cord.* Exposed cord, either in the breaker or carcass ply, must not exceed one percent of the buffed total tread area on one spot or more than two percent for the entire tire. Exposed fabric shall not exceed one carcass ply in depth.

(b) *For low speed tires.*

(1) *Bead Injuries.* Repairs may be made where only the chafe resistant material is damaged or loose, or where minor injuries do not penetrate into more than 25 percent of the tire plies up to three damaged plies.

(2) *Tread or Sidewalls.* Injuries may be repaired by the spot method. This includes cuts in the tread area that are smaller than ½ inch in length and do not penetrate more than the following number of plies into the cord body.

Ply rating	Maximum cut depth (plies)
Less than 8	
8 through 16	2
More than 16	4

12. *Retreadable Tires.* Tires with sound cord bodies and beads, or those with flat spots which do not extend into the carcass plies, are retreadable. This should be established by appropriate NDT using the equipment, techniques, and procedures which are recommended by the tire manufacturer or those outlined in the repair station's process specification approved by the FAA.

a. *Number of Retreads.* The wide variation in tire operating environments which may affect total carcass life and serviceability make it inadvisable to prescribe arbitrarily the maximum number of times a tire should be retreaded. Tire studies have disclosed that due to the complexity of aircraft tires, the propagation mechanism is critically influenced by the overall structural strength and structural uniformity of the carcass. Small separations in a weak carcass may propagate very fast while the same separation in a very strong carcass will propogate very slowly and go through many R levels before it will lead to a terminal failure. Accordingly, the number of times a tire can be recapped can only be controlled by a thorough inspection of the carcass, using all the appropriate NDT methods for each area of the carcass being inspected.

b. *Marking of Retreaded Tires.* Whenever it is necessary to replace the area containing the required original markings (Ref: TSO–C62 as applicable), or if those markings are damaged, such markings are required to be replaced. When retreading tires for certain air carriers, they may require additional tire markings. In addition, each retreaded tire sidewall should be permanently embossed with the retread information as follows:

(1) *The letter "R"* followed by a number "1", "2", etc., to signify the sequential number of retreads applied therein.

(2) *The month and year* of retread application.

(3) *The name* or identifying letters of the person who retreaded the tire.

(4) *The plant location* of the retreader.

c. *Balance Marker.* To indicate the lightweight point of the tire, remove the old balance marker and durably affix a new relocation balance marker, consisting of a single red dot of appropriate size, to the sidewall of the tire immediately above the bead. The dot should remain for any period of storage plus the retread life of the tire.

d. *Tread Design.* All tires will have a full circumferential groove tread design. The grooves will be continuous, uninterrupted, and of constant depth around the tire circumference.

e. *Tread Reinforcement Fabric.* The uppermost ply of tread fabric must be placed at least 1/32 inch below the bottom of the tread grooves to prevent cord fraying or breaking. The tread reinforcing fabric must not end directly under an outer tread groove.

f. *Balance Tolerance.* Initially an attempt must be made to balance all tires to zero unbalance, but nose tires must be statically or dynamically balanced to within one ounce of zero unbalance, and main tires must be statically or dynamically balanced to within two ounces of zero unbalance.

g. *Tire Weight.* The weight of a tire will not be greater than the applicable aircraft type certificate limitations unless specified otherwise.

h. *Balance Pads.* Balance pads must be removed prior to performing the initial liner leak check.

i. *Tire Venting.* All existing vent holes shall be rebored if not venting during air needle test or if covered during the retreading operation.

j. *Tire Dimensional Roundness Control.* Tire will be placed in a drying room at a temperature of 150°F+10°F under a relative humidity of less than 15 percent for at least twelve hours before retreading. Tires shall preferably be laid flat and supported off the floor by utilizing pallets.

13. *Nonrepairable Aircraft Tires.* If any of the following conditions exists, repair of the tire is not recommended.

a. *Injuries to the bead* or bead area (except repairs may be made where only the chafe resistant material is damaged or loose if damages do not extend into the plies of the tire and if there is no sign of separation in the bead area).

b. *Bead injuries* that affect the seal of the bead on tubeless tires.

c. *Evidence of separation* between plies or around bead wire.

d. *Injuries* requiring reinforcement and all injuries requiring sectional repair.

e. *Kinked or broken* bead.

f. *Weather checking* or radial cracks that expose body cords.

g. *Evidence of* flex breaks.

h. *Loose,* internally damaged or broken cords.

i. *Broken or cut cords* in the outside, sidewall, or shoulder area.

j. *Evidence of blisters or heat damage* to the bead seat where reversion, scorching or rubber flaking has occurred.

k. *Cracked, deteriorated,* or damaged inner liners.

l. *Flat spots and skid burns* that have penetrated more than one carcass ply.

m. *Tires that have been* heavily saturated with grease or oil.

n. *A tire run flat* or partially flat due to loss of air pressure, melting, or failure of fuse plugs should be scrapped, even though no unusual damage is evident. It is recommended that a dual mounted tire should also be removed and not repaired or reused. The only exception would be if the tire lost air and was not run in an underinflated condition.

o. *Tires when sidewalls have been buffed and veneered three times.*

14. *Certification of a Repair Station for Aircraft Tire Retreading.* A limited rating-specialized service for aircraft tire retreading is issued to an operator who desires to operate a repair station to retread aircraft tires. The wide differences in the techniques, materials and processes used by the aircraft tire manufacturers makes it necessary for a tire retreader to provide specific detailed process data for the repair and retreading of aircraft tires.

a. *Repair stations* may obtain such data from the respective tire manufacturer or may develop its own for inclusion in its process specification required by FAR Section 145.33(c). The process specification requirements are outlined in paragraph 10(b) of this AC.

b. *Since a process specification* for the retreading of aircraft tires contains in-depth details and instructions for the inspection, repair and retreading process, the document should be given a title and number by the applicant. The process specification should identify all types of tires to which the process specification applies, including qualification test reports and outlines of the procedure for the use of the specification by repair station personnel. A statement should be included to show that all changes to the process specification must be submitted to the FAA for approval before being implemented. The specification should also relate that if there are any current or future requirements of the FAR, the FAR requirements will take precedence. After the process specification is approved by the FAA, it is required to be referenced on the Repair Station Operations Specifications, FAA Form 8000–4–1 by title, number and date approved.

c. *Since the revised* TSO–C62c contains updated and improved minimum performance standards, repair stations will be required to requalify their retread process to substantiate that the process can produce a product equal to those new standards.

d. *Repair stations retreading tires* for an air carrier having a continuous airworthiness program under FAR Parts 121, 125, 127, or 135 must perform that work in accordance with the procedures as outlined in the air carrier's maintenance manual.

(1) Air carriers should assure that its maintenance manual content will provide that a retreaded tire meets the performance rules of FAR 43.13(a) and (b) and the TSO under which the tire was built or qualified by testing.

(2) Aircraft operators should consider keeping a detailed history of a tire. A copy of this record sent to the retread agency would be an asset to help determine if it would be economical for a tire to be retreaded, and possibly prevent an in-service failure of a

retreaded tire. The history should contain information such as, tire serial number, brand name, the date of manufacture, total time in service, number of landings, reasons for prior removals or repairs made to the tire during prior retreads, etc.

(3) A copy of that record should be supplied to the retread agency along with information as to why the tire is now being sent to that agency. Such as, rejected take-off, underinflation, dual mounted on axle with a failed tire, went flat static, went flat in motion, fuse plug blew, etc.

e. *The retreader's record* of work performed for each tire processed should at least contain information as follows:

(1) *Brand name.*
(2) *Tire size.*
(3) *Load rating.*
(4) *Speed rating.*
(5) *Serial number.*
(6) *Ply rating.*
(7) *Retread number.*
(8) *Skid Depth.*
(9) *Repairs made* to carcass prior to retreading and previous repairs noted that were not recorded.
(10) *Manufacturer's Part No.*
(11) *Type of tread applied.*
(12) *Plant Code.*
(13) *Month and year applied.*
(14) *Applicable TSO Number.*

f. *The retreader's quality control system* is expected to maintain a satisfactory level of workmanship throughout the retread process, including assurance that each retreaded tire meets the qualification specifications as outlined in the TSO under which the tire was built or qualified by testing. It should contain an acceptable means for determining that the methods, techniques, and practices utilized in the retread process will continue to produce a tire that meets the requirements of FAR Section 43.13, and that the work is done in accordance with the retreader's FAA approved process specification, by subjecting a representative tire to the qualification tests as outlined in the TSO under which the tire was built or qualified by testing. In addition, a representative tire of each R number escalation should also be subjected to those tests.

15. *Tire Inspection.* The life span of an aircraft tire is expected to include several retreads. In order to provide an increase in tire life span, it is necessary to subject the worn or defective tire to inspection procedures and limiting defect criteria to qualify the tire for repair, retread and return to service. Continued research is being conducted to improve tire inspection methods and criteria that will improve existing levels of tire performance, and enhance the safety of tires in service.

a. *An aircraft tire* is passed through a repair agency's inspection system to determine if the tire has defects that would make it uneconomical for retreading. The first unrepairable defect that is noted is cause for the tire to be marked for scrap and no further work is done on the tire.

b. *All repairable damage and/or defects found* are marked and identified on the work sheet for attention during the retread process.

16. *Inspection Methods.* Only three inspection procedures are now in relatively widespread use by tire retread agencies. (1) Visual, (2) air needle, and (3) holographic. Other candidate procedures require testing and validation before they can be considered effective for insuring the airworthiness of tire casings. Each procedure has limitations and should be used with full knowledge of the risks of overlooking potentially damaging defects. As inspection technology evolves, and after suitable validation, a candidate procedure will be added to these recommendations. A list and description of other candidate inspection procedures is also included in this document. Inspection procedures presently being used and evaluated by tire retread agencies are as follows:

a. *Visual Inspection.* A detailed visual inspection is the first inspection that a qualified inspector makes of an aircraft tire's outer surfaces. Any external damage that would be a reason to reject a tire for retread is usually detected during the visual inspection. Consequently, the visual tire inspection process will qualify a tire for retreading and continued service, reject it, or recommend nondestructive inspection (NDI). Visual inspection will include cuts, breaks, ply separations, exposed cords and bead damage. Specifically the visual tire inspection will include the items listed below:

(1) *Age*: Review it's history sheet, date of manufacture, use environment, number of retreads, and repair history.

(2) *Weather Checking*: Examine for sidewall checking that has exposed cords beyond repair limits.

(3) *Cuts and Punctures*: Check for injuries which have penetrated the ply structure beyond the repair limits.

(4) *Exposed Fabric*: Check for exposed fabric resulting from excessive tread wear, heavy scuffing, and bead damage that has exposed turn-up plies and/or chafer fabric.

(5) *Ply Separation*: Examine for visual signs of carcass separations in the tread, shoulder, and bead areas.

(6) *Bead Damage*: Check for bead damage that might affect the bead seal, abrasions, exposed bead wires, and evidence of excessive heat.

(7) *Internal Breaks or Ruptures*: Inspect for breaks or ruptures to the liner that will allow air to pass into the carcass.

(8) *Removal of Balance Pads*: Examine for damage to the liner, i.e. exposed fabric, etc.

(9) *Spot Repairs*: Inspect the casing to determine the need for spot repairing, determine whether the strength of the tire is affected, and approve or disapprove the repairs accordingly.

(10) *Foreign Material*: Examine the casing to ensure that the casing is free of embedded stones, nails, glass, and other foreign materials.

(11) *Pass-Fail Criteria*: See Paragraph 16b(3) this AC.

b. *Air Needle Inspection.* Aircraft tires will be inspected twice using the air needle method during each retread process. The first inspection is made after the visual inspection to check for liner and bead leaks, ply separations, and other defects such as improper venting. After the tire is repaired and the retread is cured, a second air needle inspection is acomplished to verify satisfactory vent hole function and to check for leaks, ply separations and defects that occured during retreading.

(1) *Equipment Description:* The operation requires:

(i) A rack for holding the tires in an upright position.

(ii) Hypodermic needles, 15 to 16 gauge, .050 inch ID, and approximately ½" long with special adapters allowing them to be attached to high pressure hoses.

(iii) A regulator capable of adjusting and monitoring air pressure at 125 psi.

(iv) A line trap within the system to collect moisture, oil and dirt.

(v) A portable light for close inspection work.

(vi) An air gun spray for applying leak indicator solution.

(2) *Test Method:* For the test two separate needles are inserted into each sidewall of the tire approximately 180° opposite each other. The needles are inserted in the ply turn-up region (just outboard of the annular rings) at a 45° angle to the sidewall surface with the needle point outboard away from the bead so the needle penetrates into the carcass plies taking care to use a needle length that will not penetrate the liner and cause a liner leak.

(i) The ply structure of the casing will be pressurized to 125 psi, for a minimum of 15 minutes.

(ii) The vent holes are sprayed with a leak indicator solution. Air leakage from the vent holes will verify that air pressure has migrated throughout the carcass.

(iii) Leak solution is then sprayed on the liner and over both bead areas. The surfaces are visually inspected for air bubbles, and by touch, for bulges.

(iv) Bulges are probed to determine the depth of the separation and/or cord breakage. Small isolated leakage, if only the liner, may be repairable by patching.

(v) All excess leak detector solution is cleaned from the tire. The inspection results are noted on the tire work sheets and the tire is forwarded to a drying room prior to repair or retreading.

(vi) After retreading, cleaning and trimming, the tire is given the second or final air needle test. Retreaded tires rechecked by air needle inspection station for defects, are returned to shop for correction or rejection.

(3) *Pass/Fail Criteria* described in this AC represent a consensus of industry practice and not verified test results. Tests are presently in progress to establish safe flaw sizes for tire operating condition. When these tests are complete the results will be included as part of the pass/fail criteria. When any of the following conditions become evident, the tire should be rejected:

(i) In tire sizes:

40 x 14, 20 ply rated, 120 MPH
40 x 14, 22 & 24 ply rated, 225 MPH
41 x 15, 22 ply rated, 225 MPH
(A) Shoulder separations larger than ⅜"
(B) Crown separations larger than ¾"

(ii) In tire sizes:

40 x 17, 30 ply rated, 210 MPH
50 x 20, 32 & 34 ply rated, 225 MPH
(A) Shoulder separations larger than ½"
(B) Crown separations larger than 1"

(C) Any ply separation in the bead areas, including the turnups and chafers, shall cause the tire to be rejected.

c. *Holographic Inspection.* This system uses a photographic technique to detect distortion of a tire surface in an unstressed condition as compared to that same surface in a stressed condition. The stress is applied by enclosing the tire in a controlled vacuum environment.

(1) *A photographic film* is double exposed with the first exposure of the tire surface in the unstressed position in ambient air and the second exposure of the same tire surface stressed with the tire in the vacuum chamber.

(2) *Holography is a process* of three dimensional photography that requires a coherent or single frequency light. A laser is used and the beam is split into two distinct paths. One path is called the object beam, used to illuminate the object and is reflected back from the object to the film plane. The second path is the reference beam, brought directly onto the film plane by a system of mirrors. It is the interference of the reflected light waves from the object and the reference beam that creates an interference pattern that is recorded on the film producing a "hologram."

(3) *Capillaries* in the cord plies of a tire and the micropores in the rubber contain air. The quickly induced vacuum allows expansion of this air, causing swelling of the tire and a small movement of the tire surface towards the camera. A separation defect would permit a local increase in movement or bulging.

(4) *Using the double exposure holographic technique.* small surface movements change the length of the reflected light path. This difference in optical path length creates a series of interference lines on the hologram. If the surface of the stressed tire moves uniformly toward the film plane, the interference fringe lines are horizontal and uniform. If the object contains a structural defect, it would produce distorted fringe lines in the local defect area.

(5) *Different types of structural defects* produce their own characteristic of distorted fringe lines. By learning to recognize those different types, the location, type and size of structural defects can be noted.

(6) *Bead to bead inspection* is readily available with holographic nondestructive testing using two different techniques, inside mirror view or outside camera view. Due to the complex shape of the tire, the crown, shoulders and mid-sidewall regions are inspected together in one view from the inside. The lower bead region can be viewed from the inside by inserting mirrors into the tire and looking at the reflected image. There is currently available a camera which can view the crown, shoulder and mid-sidewall areas from the inside and can be moved from the inside to the outside of the tire to view the lower bead region from the outside. This transition from the inside to outside can be accomplished in a matter of seconds.

(7) *Equipment Description:* Holographic equipment is available commercially and consists of the following:

(i) A platform supporting a turntable upon which the tire is mounted for inspection.

(ii) A laser and interferometer mounted on the same platform so that a fixed relationship with a tire can be maintained. All elements involved in the photographic process are uniformly vibration isolated on the platform.

(iii) Camera and interferometer optics mounted at the center of the turntable.

(iv) A dome over the entire assembly within which a partial vacuum may be created.

(v) A device used to spread the tire beads for the insertion of spreader bars.

(vi) A hologram viewer illuminated by a laser light source. Adequate floor space is necessary for the flat storage of tires, while allowing for dimensional stabilization after spreading.

(8) *Inspection Procedure.*

(i) The tire's beads are spread apart and the tire is allowed to stabilize for about 30 minutes.

(ii) The tire is loaded on the machine's turntable and fixed into position; the dome is brought down over it.

(iii) The tire is illuminated by a laser and is photographed.

(iv) Without moving the tire, a vacuum is induced within the chamber and the tire is again photographed, double exposing the hologram.

(v) Steps (iii) and (iv) are repeated until all four quadrants of the tire have been photographed.

(vi) The film is developed and the hologram is read.

(9) *Pass/Fail Criteria.* See Paragraph 16b(3) of this AC.

d. *Other Nondestructive Inspection Techniques.* Several promising techniques are beginning to be considered for aircraft tire integrity confirmation. While some show great potential, none has the ability to consistently demonstrate the ability to find flaws related to tire airworthiness. The criterion for acceptance of a potential technique should answer to the question: "Is the technique valuable in identifying tires which may fail to remain airworthy during the next cycle between retreads?" No known inspection method can find all flaws, but several have proved to be cost effective in reducing the number of tire removals between retreads, when used in the appropriate circumstances. As nondestructive technology evolves, new methods will become available which meet these criteria. The FAA in its approval procedure will compare the proposed overall inspection procedure to the anticipated maximum service severity of the carrier, in order to determine whether the procedure provides the necessary safeguards to maintain tire airworthiness. It is presently recognized, that a method for efficient casing selection prior to retreading tires is essential for an overall tire quality assurance program. Some of the other nondestructive inspection techniques are:

(1) *Air Needle Buffing.* This is accomplished on a machine designed to permit tire buffing and air needle inspection at the same time.

(i) The tire to be inspected is installed onto the expandable rim of the tire buffing machine. The rim is expanded by air pressure and the tire is inflated by air pressure to force the beads outward against the rim flanges and firm the tire to its inflated position. The air needles are put in place and the tire is slowly rotated to check needle hoses for clearance while rotating.

(ii) The buffing operation is started in a normal manner. As the heavy tread and shoulder rubber and tread reinforcement plies are buffed off, separation may become apparent on the buffed surface since outward surface bulges are no longer suppressed by the heavy outer rubber.

(iii) The machine operator continually observes the surface for separation evidence and may stop the machine for closer inspection. Carcass ply separation is cause for disqualifying a tire for retread. Isolated separations between outer carcass ply and undertread rubber may be repairable.

(2) *X-ray Method.* Present day X-rays use a video image of a flouroscope screen for direct observation by the tire inspector in place of the use of film to record a tire image.

(i) The machinery used is composed of two enclosures that are air conditioned. The radiation enclosure houses the tire manipulator, and drive the X-ray source, generator system, cooling system, and the image system. The second is the operator enclosure that houses the systems controls and the operator's video display used during inspection. A radiation protective window is provided adjacent to the console so the operator has a direct view of the tire as it is manipulated during the inspection.

(ii) Analysis of defective areas in the structure of a tire requires a knowledge of tire construction. Anomalies appear as an area of greater distinguishable brightness than the surrounding area of similar construction for surface gouge or some separations. X-ray detects the tire construction components by their relative transparency to radiation. A single ply flaw in a multi-ply tire cause a small difference in overall X-ray transparency and is difficult to detect. In tires that contain multiple bead wire bundles, one bundle screens the X-ray penetration from the others and they are difficult to view. X-ray has a limited use in the inspection of a tire carcass.

(3) *Ultrasonic* is a system that uses sound waves passed through the tire to inspect the integrity of the laminated structure of the tire. The tire being inspected by a sonic method may be surrounded by various media, usually air or water, through which the sound travels from transmitter to the tire and then to the receiver. Testing in a media is necessary since the transducers are not in direct contact with the tire surface. By detecting the changes in sound wave transmission, it is possible to detect anomalies in the tire. Following are two systems in general use.

(i) *Through-Transmission.* This type uses a device (transducer) to generate sound waves near one surface of the tire and one or more receivers on the opposite side of the tire to detect the sound wave and converts the intensity of the received sound into an electrical voltage signal which is displayed as a wave form trace on an oscilloscope. When a ply separation or other tire defect is in the path of the transmitted sound, the wave form is changed in relation to the anomaly. A ply separation makes a noticeable reduction in the intensity of the sound at the receiver,

causing an altered wave form. A comparison of the altered wave forms displayed when the sound is received in an area of the tire containing a defect, with a region of the tire without a defect confirms the presence of the defect and usually shows the type and size of the anomaly.

(ii) *Pulse-echo.* This system also uses transducers to transmit a sound wave at very short intervals and to receive the delayed reflected sound waves from the intersurface of the tire laminate layers in the path of the transmitted waves. The reflected sound waves or echos from successive laminations are received at successively later times as the distance traveled by the transmitted and reflected sound increases. Each layer in the tire laminate affects the reflected wave froms in accordance with the layer material's sound transmission and sound impedance characteristics, as does an anomaly within the laminate. On an oscilloscope display the wave form differences can be evaluated to determine the type and extent of tire anomalies.

e. *100 percent tire inspection.* A review of tire studies shows that no single NDT inspection method can detect all the possible unsafe tire defects. It is therefore necessary to use multiple tire inspections to cover the entire tire structure to locate all possible defect areas.

(1) In order to quickly identify a tire that is not economical for retreading, it is recommended that the visual inspection should be done first in conjunction with an air needle inspection to check for liner leakage and vent hole function. This should provide identification of liner leaks to be considered for repairs or scrapping of the tire and to check the integrity of any earlier repairs. After those inspections, advanced NDT methods should than be used to further qualify a tire carcass for retreading.

(2) The holographic inspection method is the primary advanced method which is used on aircraft tires as a routine retread qualification method. It is used to search for separations in the bead, mid-sidewall, shoulder, and crown areas of tires and to check the overall structural integrity of a tire carcass as related to defects such as separation, poor adhesion, weak or loose splices, undercure, flex breaks, integrity of repairs, and porosity. Holographic tire inspection equipment in commercially available, and, considering the vast background experience in the process and analysis, this is ideal for use after the initial inspection to further qualify tires for retreading or as a final inspection to qualify the retread process.

(3) There is no off-the-shelf ultrasonic test equipment available for aircraft tires. Until such equipment is available, its use will be limited.

(4) X-ray inspection equipment is commercially available for aircraft tires and is used widely for examination of tire construction, but little of it is used for the qualification of aircraft tires for retread.

17. *High-Speed Tire Maintenance and Operational Practices.* Studies show that tire failure and carcass deterioration of inservice tires can be alleviated by proper maintenance and operational practices. Advisory Circular No. 20–97 provides information on the causes of aircraft tire failures and methods of increasing tire reliability. This advisory circular is available from the U.S. Department of Transportation, Publications Section, M–443.1, Washington, D.C. 20591.

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